PAGAL LAB | INERTIA X1

User Manual v1.3.1

INERTIA X1 — User Guide

1. Introduction

Welcome to the Inertia X1 system. This application, combined with the Inertia X1 mechanical device, turns your smartphone into a precision laboratory for tennis racket analysis. Using the phone's inertial sensors (gyroscope) and advanced physical analysis algorithms, Inertia X1 can measure Swingweight (moment of inertia) with professional accuracy.

2. Installation and First Launch

The Inertia X1 application is available in two versions optimized for your platform:

Download via QR-Code

Scan the QR-Code found in the Inertia X1 packaging with your smartphone camera. The system automatically detects your device and starts the correct installation process:

- **Android:** the native app optimized for Android is installed automatically. If prompted, confirm the installation by following the on-screen instructions. Once complete, the Inertia X1 icon will appear on your phone like any other app.
- **iOS (iPhone/iPad):** the application opens in Safari browser. Tap the Share button → Add to Home Screen to install the icon on your home screen and access the app in optimized mode.

> The QR-Code also contains the calibration configuration specific to your instrument (serial number, sample inertia values and alignment parameters). Each instrument has its own unique QR-Code: do not swap it with other instruments.

3. Leveling and Calibration

The fundamental principle of Inertia X1 is that calibration automatically compensates for any non-perfect verticality of the rotation axis. There is no need to chase precise angular values: it is sufficient to position the instrument in a reasonably stable way and not move it between calibration and the end of the measurement session.

Step 1 — Axis verticality (rear foot)

Remove the smartphone from the cradle and lay it vertically on the calibration bar in portrait position. In the Calibrate tab, observe the longitudinal angle shown by the digital level: it should be close to 0°. Adjust the rear foot until the value is approximately horizontal (±0.5°).

Step 2 — Centering the equilibrium point (front feet)

This step is the most important for measurement quality. The goal is not to achieve a precise angle, but to mechanically center the equilibrium point of the oscillating support.

- Bring the support into contact with the left stop and release it. Observe whether it spontaneously reaches the opposite stop without touching it.
- Repeat from the right side.
- Adjust the front feet until the support, released from either side, never touches the opposite stop.

When the support stops spontaneously before touching the opposite stop from both sides, the equilibrium point is centered and the instrument is ready for calibration.

Step 3 — Calibration

Perform calibration with samples A and B without moving the instrument. From this point the instrument is ready for the measurement session.

> Fundamental rule: do not move the instrument between calibration and the end of the measurement session. If the instrument is moved — even just to a different table — it is necessary to repeat Steps 1, 2 and calibration.

Calibration Samples

Two calibration bars made of high dimensional-stability polymer, CNC lathe-machined, are supplied with the instrument. The inertia is calculated from the 3D CAD model and verified in the lab for the two configurations:

- Sample A: light configuration (lower inertia), composed of the two bars screwed together.
- Sample B: heavy configuration (higher inertia), obtained by screwing the supplied screw into Sample A configuration.

The exact inertia values are specific to your instrument and loaded automatically on first QR-Code scan. They are also available in the Calibration Certificate.

Guided Calibration Procedure (Standard Mode)

Two-point calibration correlates the oscillation period to the moment of inertia. The guided procedure consists of 5 phases:

Phase 1 — Start and Preparation

- Access the Calibrate tab. Tap START WIZARD.

Phase 2 — Sample A Calibration

- Fix Sample A, rotate to the stop, press START, wait for RELEASE, release.
- The system requires 3 valid measurements. Measurements with disturbances are automatically discarded.

Phase 3 — Switch to Sample B

- Mount Sample B, tap I HAVE MOUNTED SAMPLE B, perform 3 valid launches.

Phase 4 — Final Verification

- Remount Sample A, tap I HAVE REMOUNTED SAMPLE A, perform one verification launch.

Phase 5 — Completion

- A confirmation message will appear. Calibration is saved and the instrument is ready.

Calibration in Advanced Mode

Advanced mode allows free sample selection, any number of measurements, and selective discard of less accurate measurements before confirming.

Advanced mode is recommended for expert users. For daily use, the guided procedure guarantees optimal results with minimum effort.

4. Swingweight Measurement

Once calibration is complete, the instrument is ready to analyze your rackets. Measurement takes place in the Measure tab.

Measurement Sequence

- Insert the racket handle into the support with the butt cap touching the base. Tighten the locking strap.
- Rotate the support to the angular stop and hold it steady.
- Tap START, wait for the acoustic signal and the orange RELEASE button.
- Gently release the support without guiding it.
- The app acquires 7 half-waves after discarding the first 2 (approximately 6-7 seconds).
- A double acoustic signal announces the result.

Do not touch the instrument or the table during oscillation. Even minor vibrations can affect the result.

Spinweight and TwistWeight Measurement

- **Spinweight:** mount the racket with the string bed horizontal and activate the MEASURE SPINWEIGHT ALSO toggle before starting.
- **Estimated TwistWeight:** automatically calculated as the difference between average spinweight and swingweight measurements. Displayed in amber.

5. Archive

The Archive tab is the data management center. Organize rackets, consult measurement history and analyze each launch. The Lab Diagnostic v2 panel (microscope icon) gives access to in-depth signal analysis for the last 10 measurements.

Parameter	Description	Reference values
Reliability	How consistent the launch was with an ideal harmonic oscillation.	≥ 90% excellent — < 70% repeat
Stability	Period variation between half-waves of the same launch.	Excellent < 0.2% — Acceptable < 1.5%
Asymmetry	Percentage difference between positive and negative half-waves.	Normal < ±3% — Max ±5%
Damping	Amplitude decay rate. Depends on bearing friction.	Optimal 0.005–0.100
Sampling Quality	Regularity of gyroscope sampling.	Good ≤ 1.5ms — Fair ≤ 4ms — Poor > 4ms
Sampling Rate	Data read per second from the phone sensor.	Typically 60–100 Hz

6. Info Section

The Info tab is the control center for settings. Includes: system information, language selection, mode selection, version changelog, memory management (backup, import, export diagnostics) and remote analysis instructions.

Versions and Updates

This section shows the app version changelog. Updates are distributed automatically: the next time you open the app you will always find the latest version. If a new version is available, the app notifies you with a banner at startup.

7. When to Recalibrate

Repeat the calibration procedure if:

- You change smartphone or remove the phone case.
- The instrument is moved to a surface with significantly different stability.
- You notice a systematic drift in Swingweight values on known reference rackets.

> A simple table change does not require new calibration if the instrument has not been moved. If it has been moved, repeat leveling and calibration.

8. Troubleshooting

Symptom	Probable cause and solution
Reliability < 70%	Imprecise release, external vibrations, or racket not properly locked. Check tightening and repeat.
Damping > 0.100	Excessive friction on bearings. Contact technical support.
Asymmetry > ±5%	Release with too much energy or support not centered. Repeat Step 2 of leveling.
Non-repeatable SW values	Check racket tightening, that the table is not vibrating, and that the instrument has not been moved after calibration.

9. Legal Notes and Contacts

For assistance: info@pagal-lab.com

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